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WADC TECHNICAL REPORT 52-228

AD-7224

COMPLETE TYPE TEST OF AEROPRODUCTS TWO-BLADED PROPELLER, MODEL NO. A422-69 (Whirl Test No. 2273)

ROBERT R. STEPHENSON, 2D LT, USAF
PROPELLER LABORATORY

SEPTEMBER 1952

NOTE: Distribution of this report except to Government agencies will not be made without prior approval of the Propeller Laboratory, WADC.

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WADC TECHNICAL REPORT 52-228

COMPLETE TYPE TEST OF AEROPRODUCTS TWO-BLADED PROPELLER, MODEL NO. A422-69 (Whirl Test No. 2273)

Robert R. Stephenson, 2d Lt, USAF
Propeller Laboratory

September 1952

SEO No. 580-326

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

This report was prepared by the Propeller Laboratory, Wright Air Development Center, under Service Engineering Order No. 580-326, "Aeroproducts Propellers for XBT-28 Airplane," Whirl Test No. 2273. The propeller was procured under USAF Contract No. AF 33(038)-1174 from Aeroproducts Division, GMC, and delivered to the Propeller Laboratory for test. Tests were conducted from 3 March 1949 to 5 June 1950. Administration of the test was under the direction of Messrs. D. C. Hayne and D. F. Hild, project engineers.

ABSTRACT

The type testing of the Aeroproducts Model A422-69 Propeller, intended for use on the T-28 type aircraft, is described. The testing included complete calibration, endurance, and overspeed running on the electric motor whirl rig, plus endurance running and control operation on the R-1300-1 engine. As a result of the testing, two changes were made in the propeller; a change of the control ring material to a nitriding steel, and an increased diameter of the control ring guide pin.

It is concluded from this testing that the Aeroproducts A422-E1 propeller is satisfactory for use on the T-28 aircraft in combination with the R-1300-1 engine.

PUBLICATION REVIEW

This report has been reviewed and is approved.

L. M. Taylor

L. M. TAYLOR
Colonel, USAF
Chief, Propeller Laboratory
Directorate of Laboratories

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ILLUSTRATIONS
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COMPLETE TYPE TEST OF AEROPRODUCTS TWO-BLADED PROPELLER, MODEL NO. A422-69

PURPOSE OF TEST

This test was conducted to determine the suitability of the Aeroproducts production Model A422-E1 propeller assembly for use on the T-28 aircraft equipped with Wright Aeronautical Division R-1300-1 engines. It was also desired to calibrate the propeller for horsepower and thrust in accordance with the propeller type test specification, MIL-P-5452.

DESCRIPTION OF TEST PROPELLER

The propeller used in this test was an Aeroproducts Model No. A422-69 self-contained, hydraulically operated, constant speed propeller assembly which was the experimental prototype of the production propeller, Model No. A422-E1. There are no major differences between the two propellers. The A422-69 propeller was fabricated in the model shop with component parts bearing experimental part numbers, whereas the A422-E1 assembly is fabricated in the production facilities and has production part numbers.

The propeller is a two-blade, ten foot and one-half inch diameter propeller with forged thrust member, hollow steel blades, Aeroproducts Model No. H20H1-162-40M5, having constant chord from the 27 to the 42 in. station. It is nonfeathering and nonreversing.

The design conditions for the propeller on the R-1300-1 engine are as follows:

Take-off	- 800 bhp at 2600 rpm (engine) (1462, propeller)
Normal Rated	- 700 bhp at 2400 rpm (engine) (1350, propeller)
Propeller Gear Reduction	- 0.5625:1
Polar Moment of Inertia	- 3424 slug-in.^{2}
Weight (Wet)	- 234.5 lb.

The propeller hub is for a No. 40 engine shaft, supporting No. 2 shank blades. The pitch change mechanism is designed to give a blade angle travel of 40° from 23.2° low angle to 63.2° high angle. Pitch change is effected by the standard Aeroproducts hydraulic torque units, Reference 1.

The regulator is hydraulically operated, having a spring loaded, centrifugal governor valve. Speed control is effected by movement of the regulator control lever located on the back of the regulator.

Figures Nos. 1 and 2 show the configuration of the A422-69 propeller assembly.

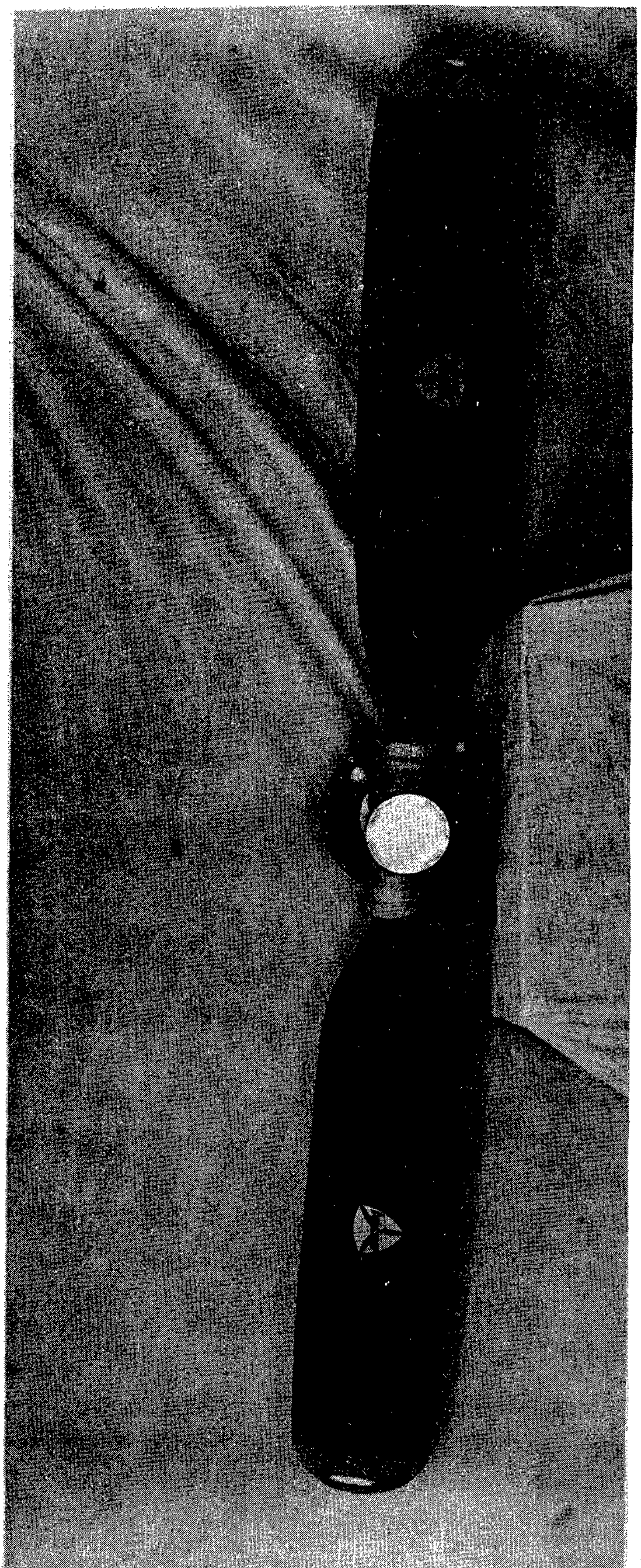

Fig 1 - Front View, Aeroproducts Propeller, Model A422-69/H20H1-162-40M5

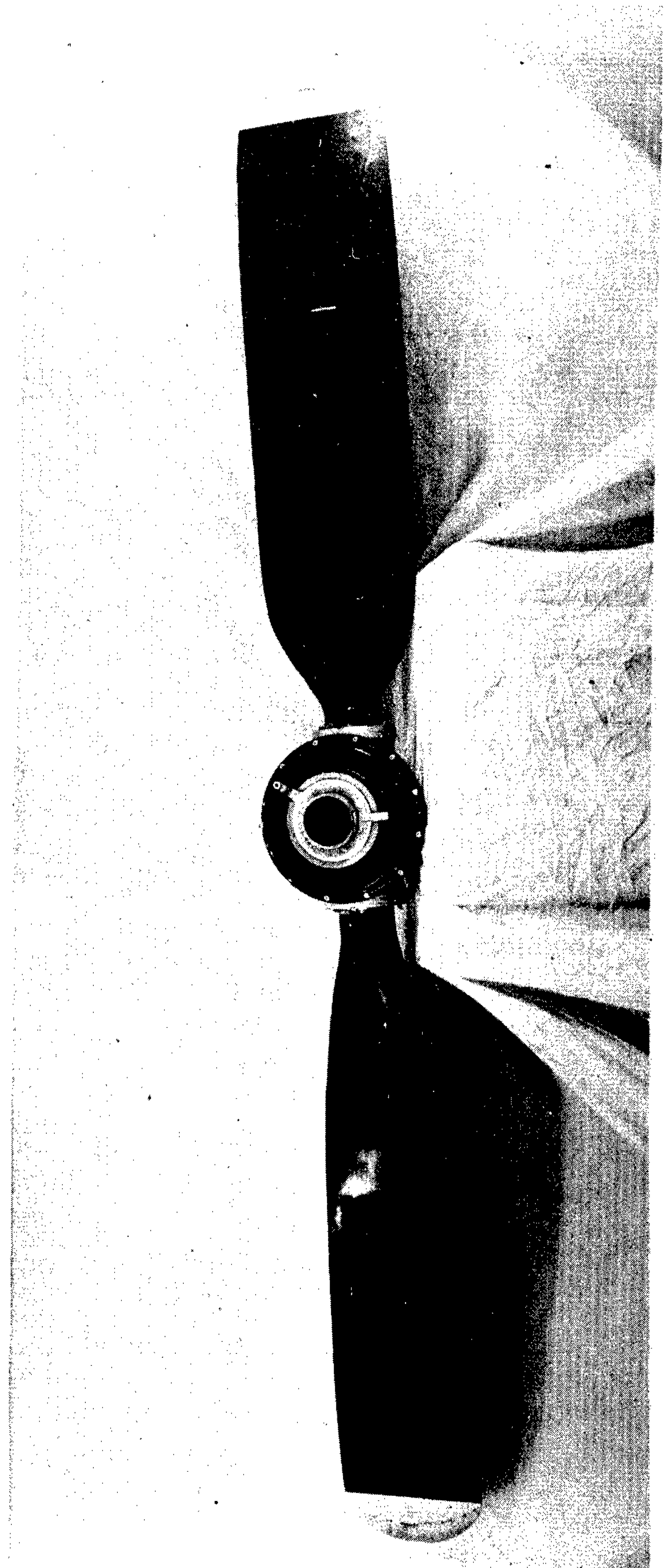

Fig 2 - Rear View, Aeroproducts Propeller, Model A422-69/H20H1-162-40M5

DESCRIPTION OF TEST

ELECTRIC MOTOR WHIRL TEST

The propeller was assembled, balanced, and checked for track in the Propeller Shop of the Propeller Laboratory. It was then installed on Whirl Rig No. 3 for the electric motor portion of the test.

Eight calibrations of the propeller were made, one at each of the following fixed pitch blade angles: 13.2, 17.9°, 23.2°, 26.5°, 28.2°, 33.2°, 38.2°, and 43.2°. The horsepower curves are plotted in Figure 3, and the thrust curves are plotted in Figures Nos. 4, 5, and 6.

Deflection observations were made during the above calibrations and are presented graphically in Figures 7 through 14. Tabular presentation of these data is given in Tables 1, 2, and 3.

One hour overspeed of the propeller was satisfactorily completed at 1776 rpm with the blade angle at 17.9° and the propeller absorbing 696 hp. Overspeed was based on 110% of maximum allowable engine speed or 1770 rpm.

The 20 hour endurance test was satisfactorily completed at approximately 1640 rpm with the propeller absorbing 1325 hp. For this run, the blade angle was set at 26.5°. During the endurance run, parts of which were conducted on each of four days, the propeller speed had to be varied from 1630 to 1663 rpm to maintain constant power, depending on atmospheric conditions and air inflow to the propeller.

No defects in the propeller were observed during this portion of the test or at inspection after testing.

ENGINE TEST

Engine testing of the propeller-engine combination was begun on a new Wright Aeronautical R-1300-1 engine. The schedule of test operation included a basic cycle of ten 1 hour endurance runs plus ten control operations, followed by one hour at take-off conditions and 70 control operations. Repeating the basic cycle ten times made up 100 hours endurance, 10 hours take-off, and 1700 control operations.

The 100 hours of endurance running were divided into 50 hours at normal rated power and speed (2400 rpm and 34.6 in. manifold pressure) and 50 hours at a high engine vibratory stress condition (1900 rpm and 30.8 in. manifold pressure).

Complete inspections of the propeller, including a teardown of the regulator, were made following each 25 hours of operation. In addition, daily visual inspections of the propeller were made.

Two vibratory stress surveys were made prior to endurance running on the propeller to insure that the stress levels encountered on the engine were less than the allowable limits. Since the stresses were within safe limits, continued monitoring of the stresses during the remainder of the test was not necessary.

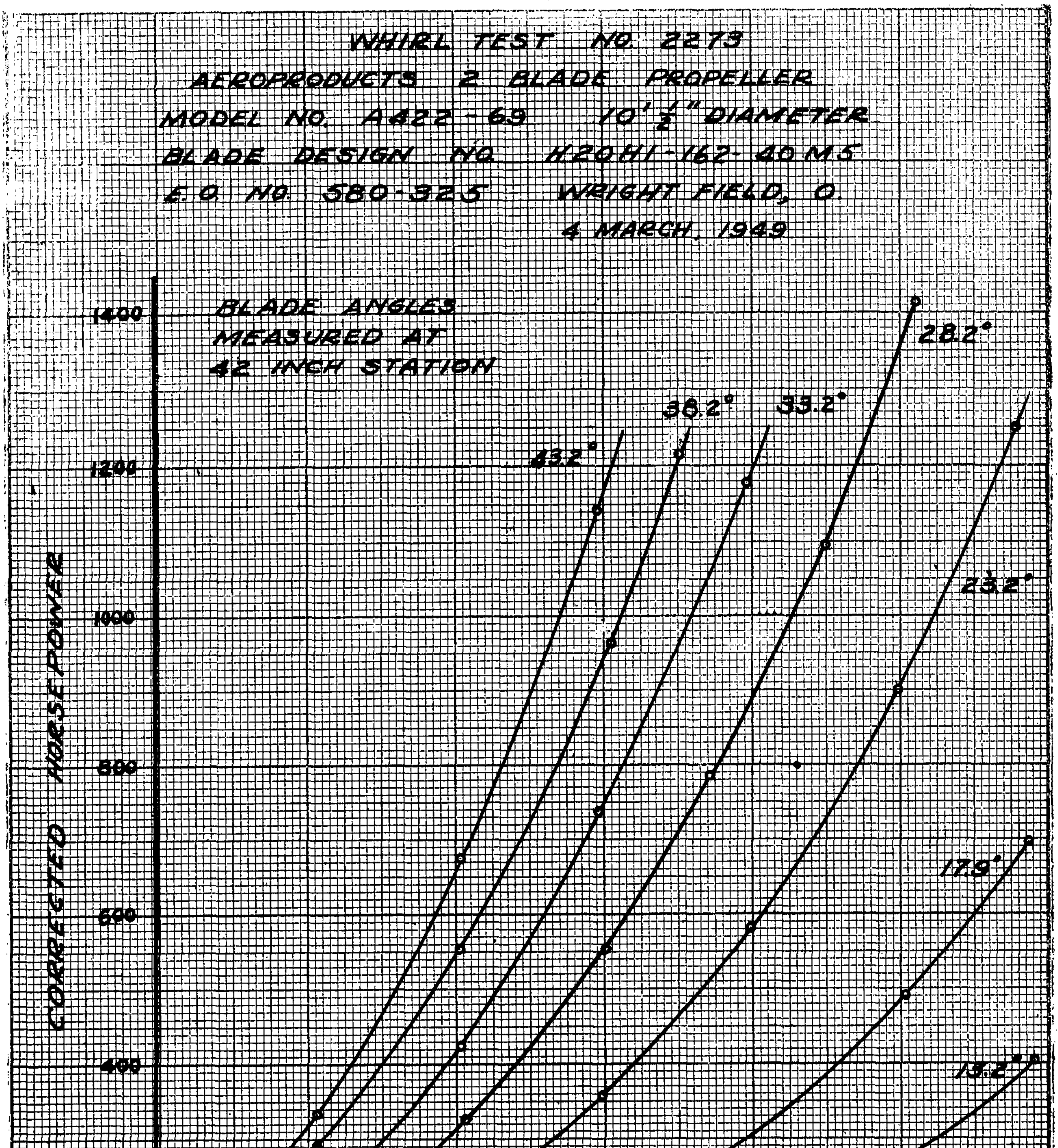

Fig 3 - Corrected Horsepower Plotted Against Propeller RPM Aeroproducts Model A422-69 Propeller

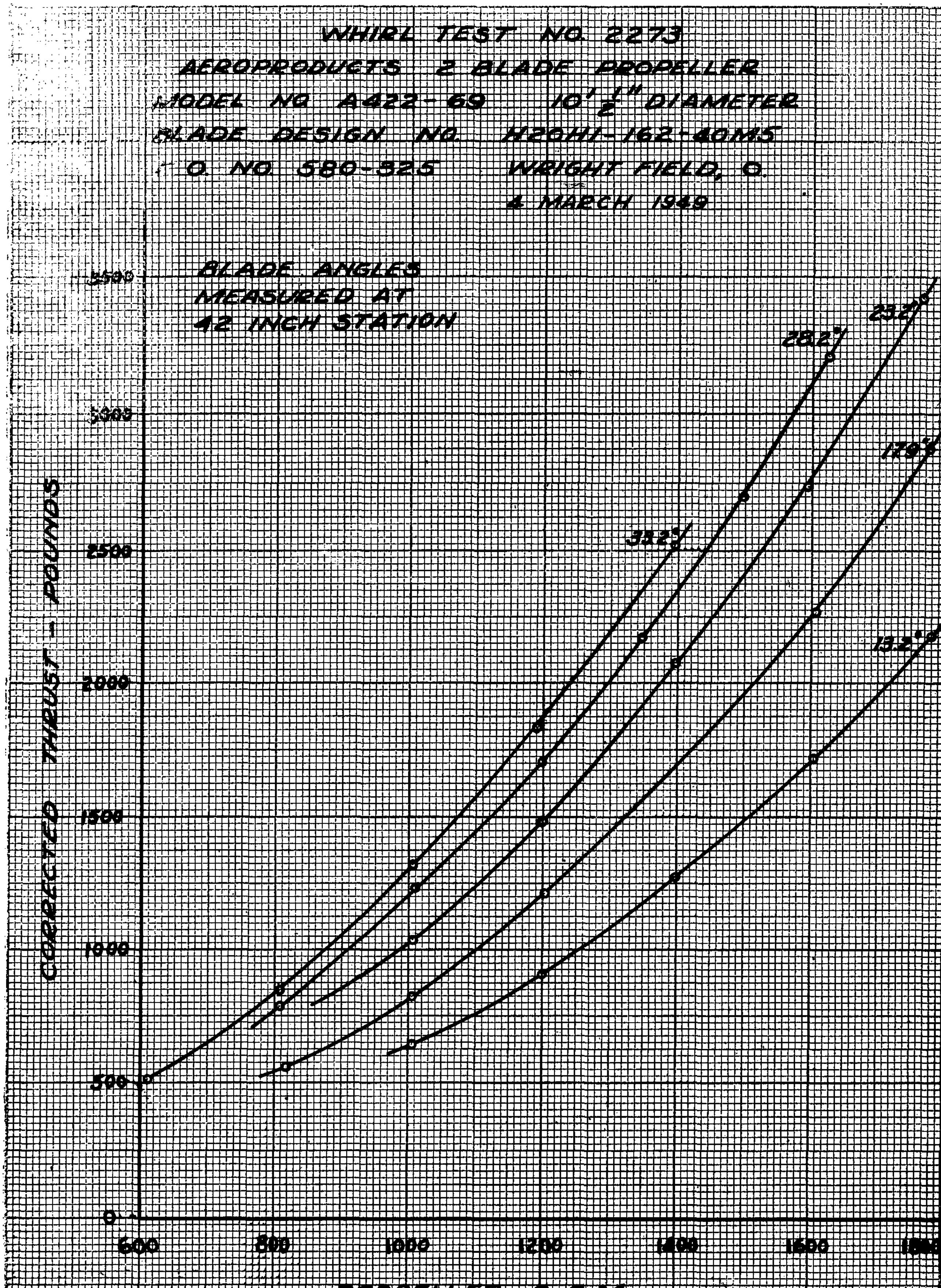

Fig 4 - Corrected Thrust Plotted Against Propeller RPM Up to 33.2° Blade Angle. Aeroproducts Model A422-69 Propeller, W.T. No. 2273

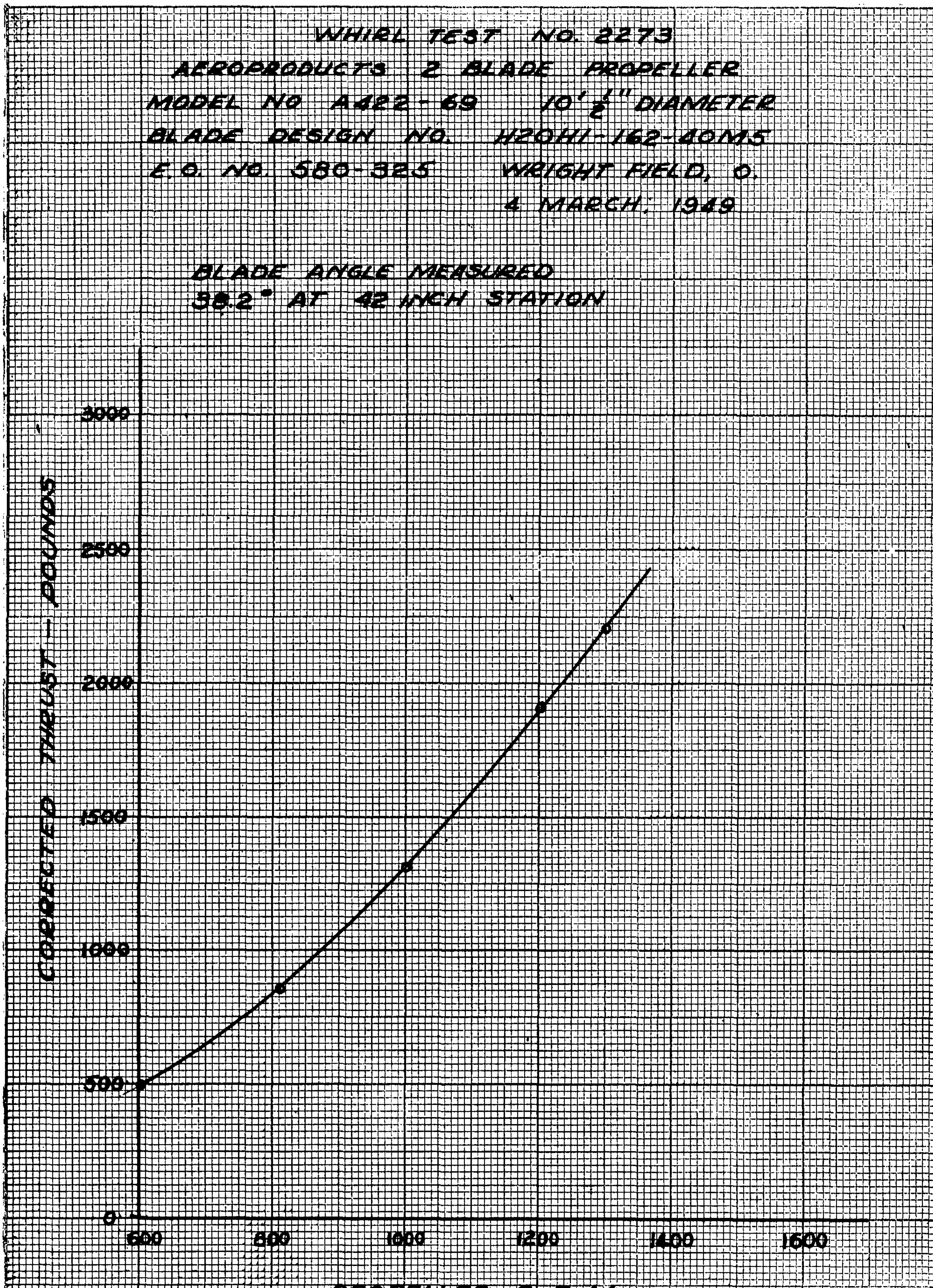

Fig 5 - Corrected Thrust Plotted Against Propeller RPM, Blade Angle 38.2°, Aeroproducts Model A422-69 Propeller, W.T. No. 2273

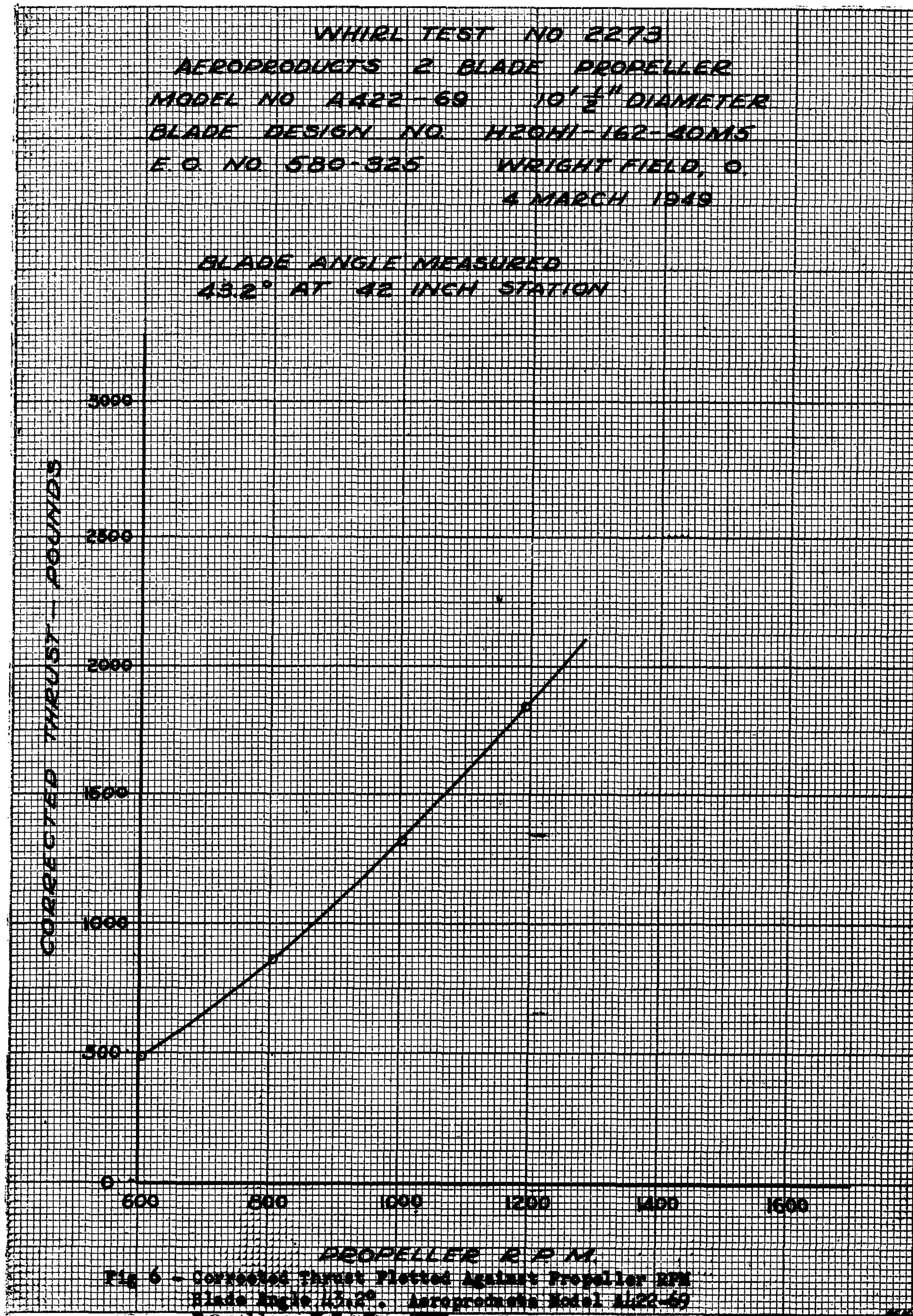

Fig 6 - Corrected Thrust Plotted Against Propeller RPM
Blade Angle 43.2°. Aeroproducts Model A422-69
Propeller, W.T. No. 2273.

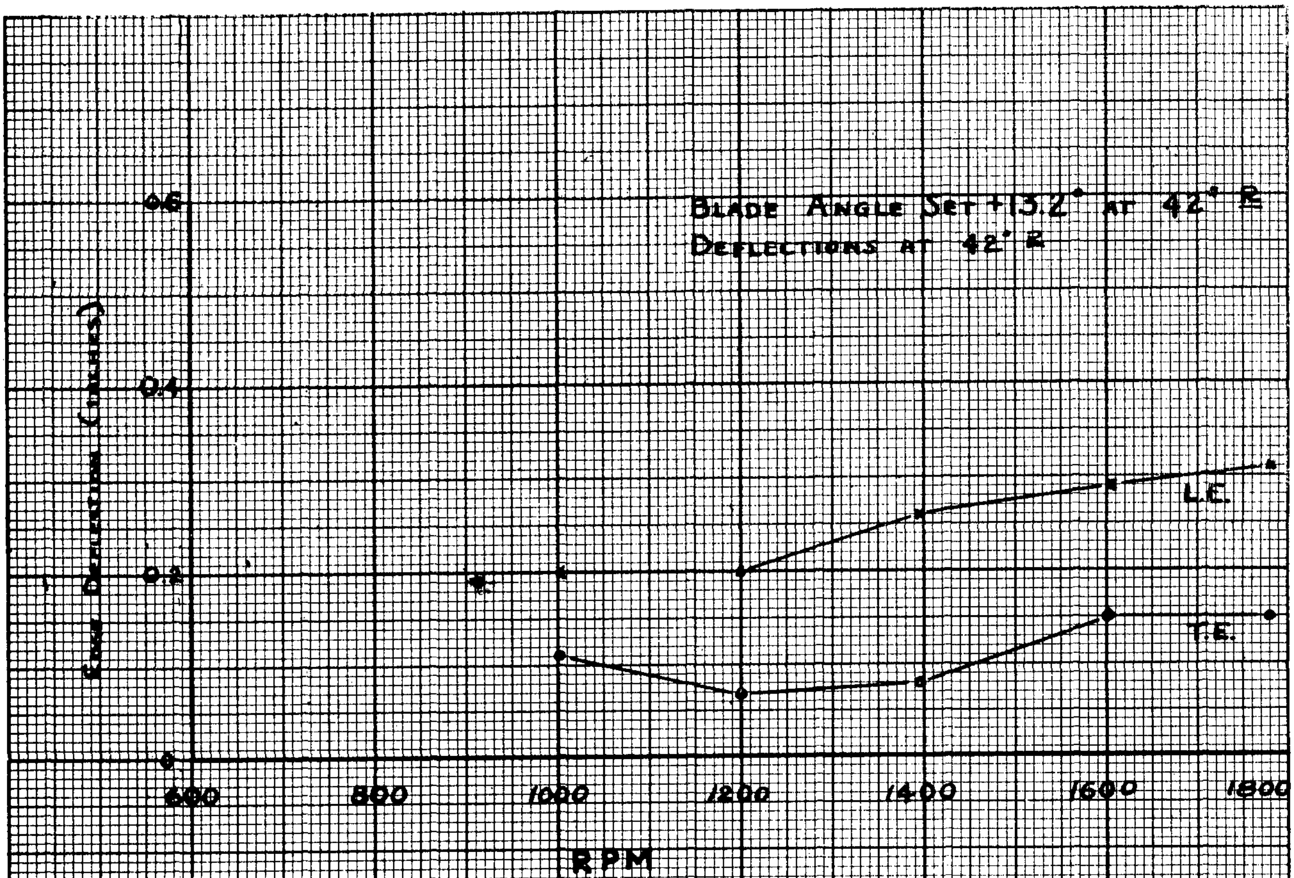

Fig 7 - Blade Deflection Plotted Against RPM Aeroproducts Model A422-69 Propeller. 13.2° Blade Angle.

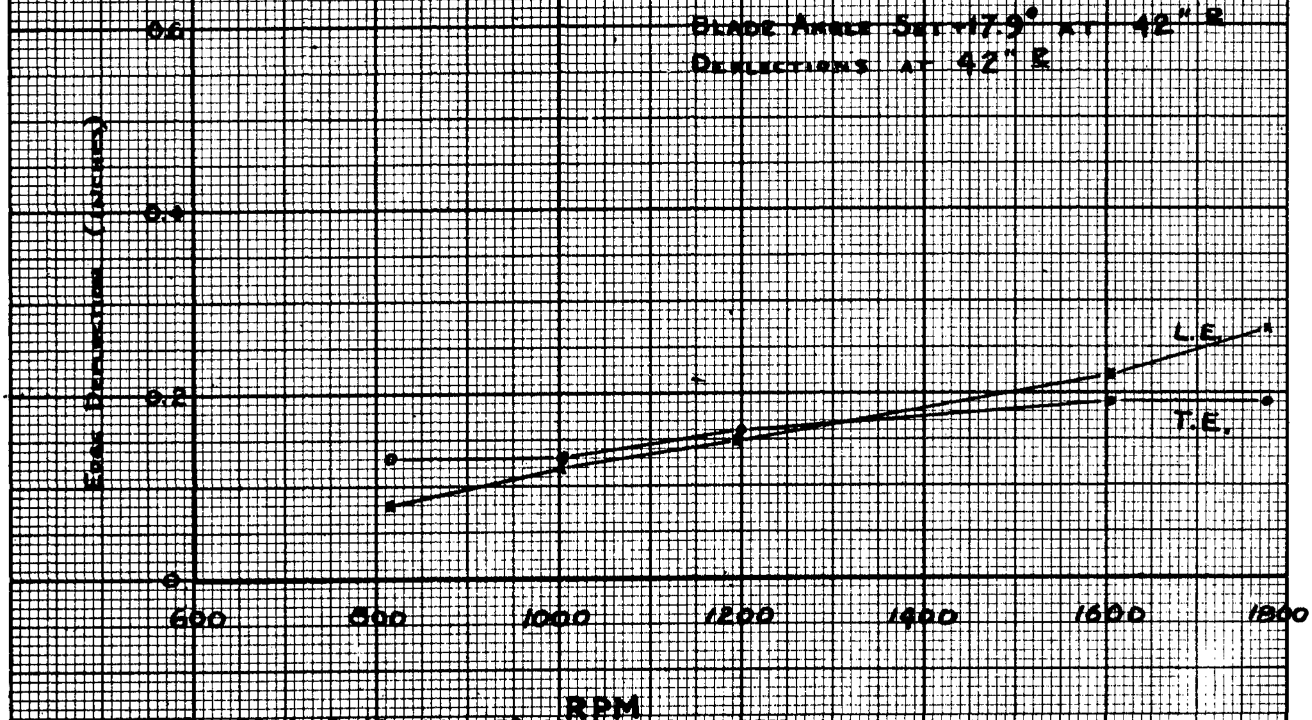

Fig 8 - Blade Deflection Plotted Against RPM, Aeroproducts Model A422-69 Propeller. 17.9° Blade Angle

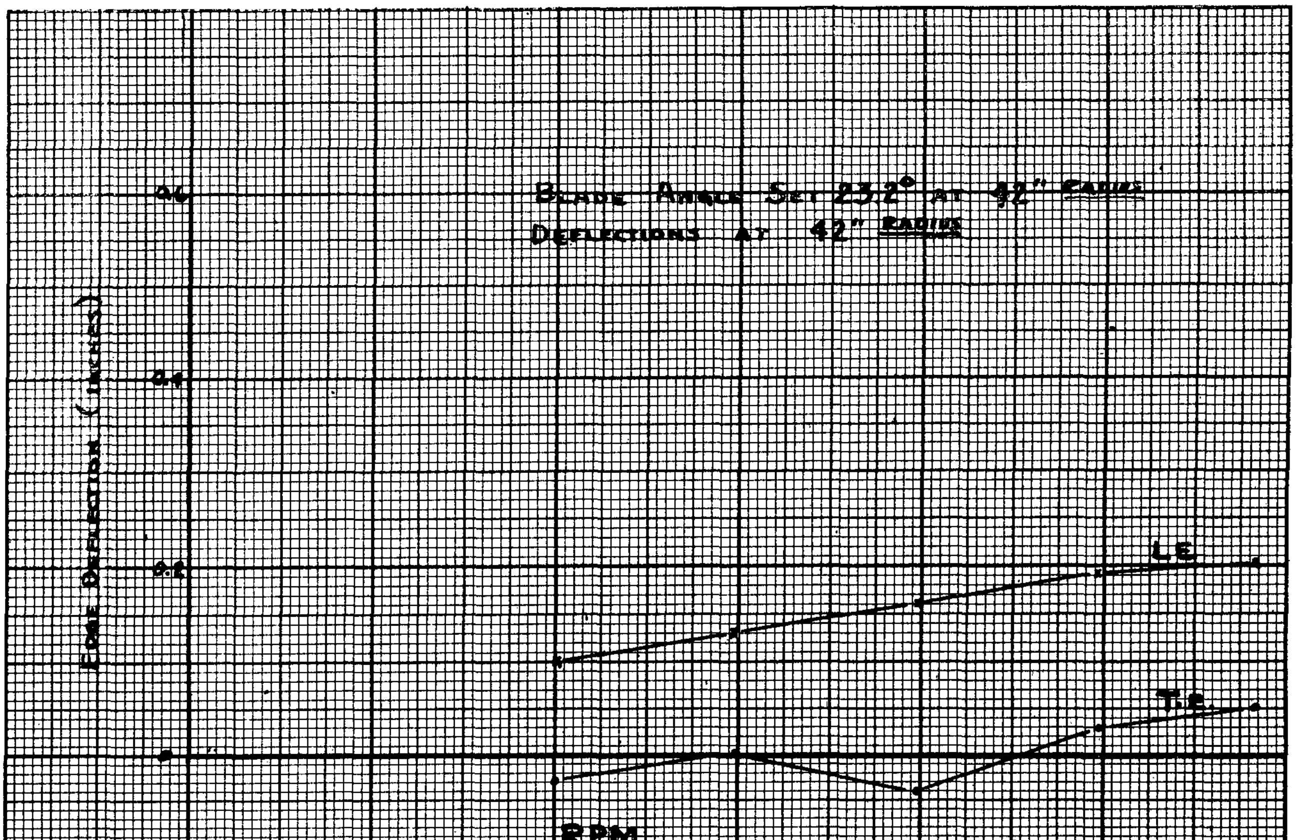

Fig 9 - Blade Deflection Plotted Against RPM, Aeroproducts Model A422-69 Propeller. 23.2° Blade Angle.

Fig 10 - Blade Deflection Plotted Against RPM, Aeroproducts Model A422-69 Propeller. 28.2° Blade Angle.

RPM

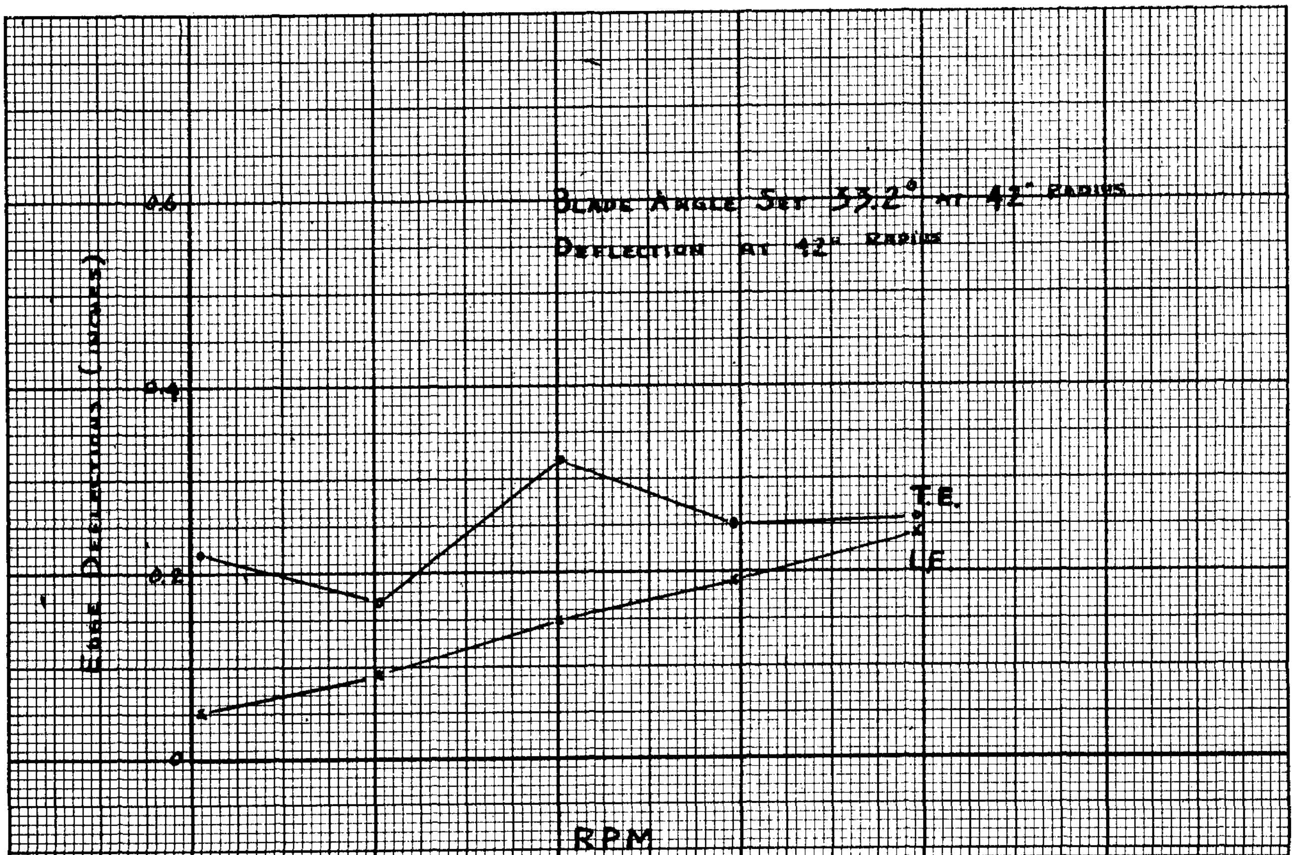

Fig 11 - Blade Deflection Plotted Against RPM, Aeroproducts Model A422-69 Propeller. 33.2° Blade Angle.

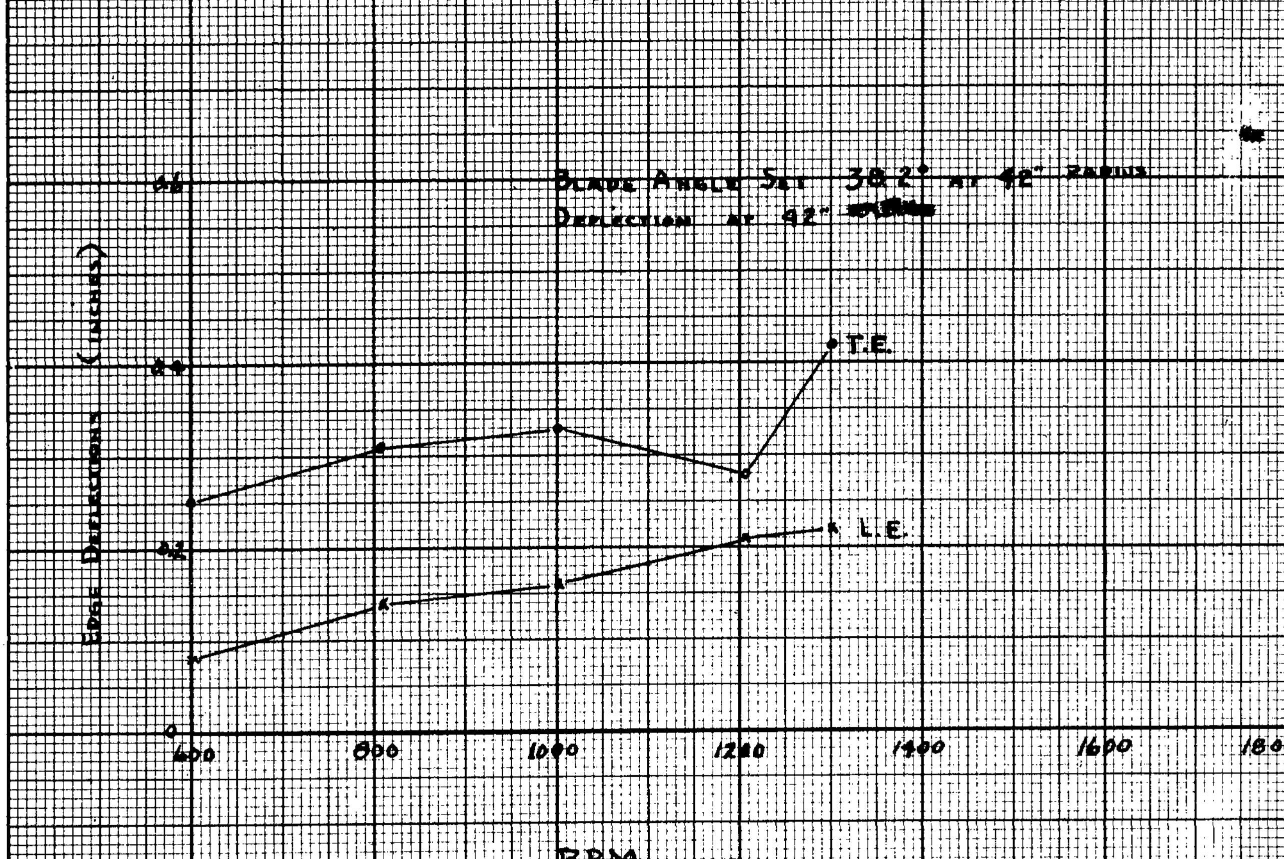

Fig 12 - Blade Deflection Plotted Against RPM, Aeroproducts Model A422-69 Propeller. 38.2° Blade Angle.

CRS

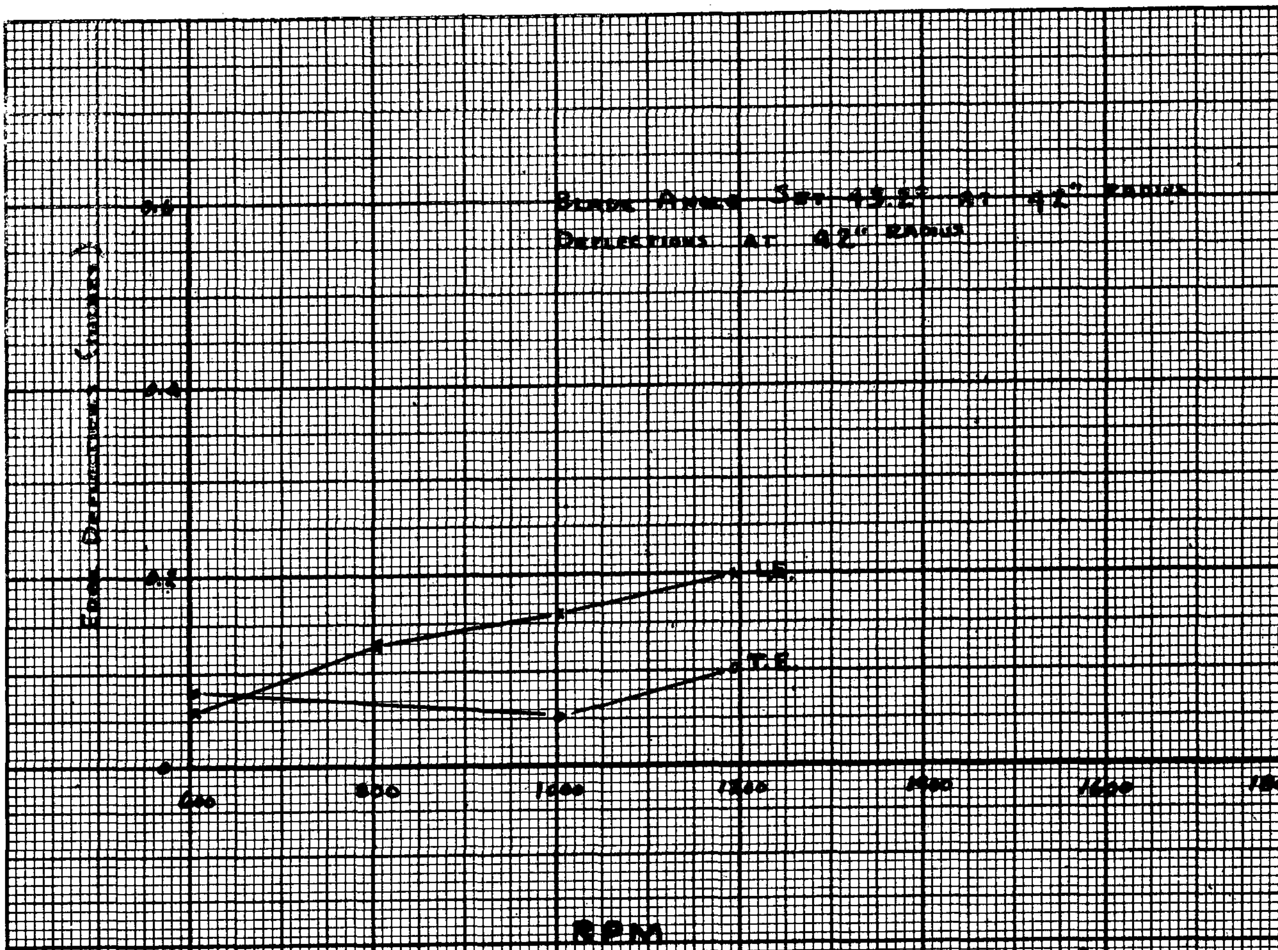

Fig 25 - Blade Deflection Plotted Against RPM, Aeroproducts Model A122-69 Propeller. 43.2° Blade Angle.

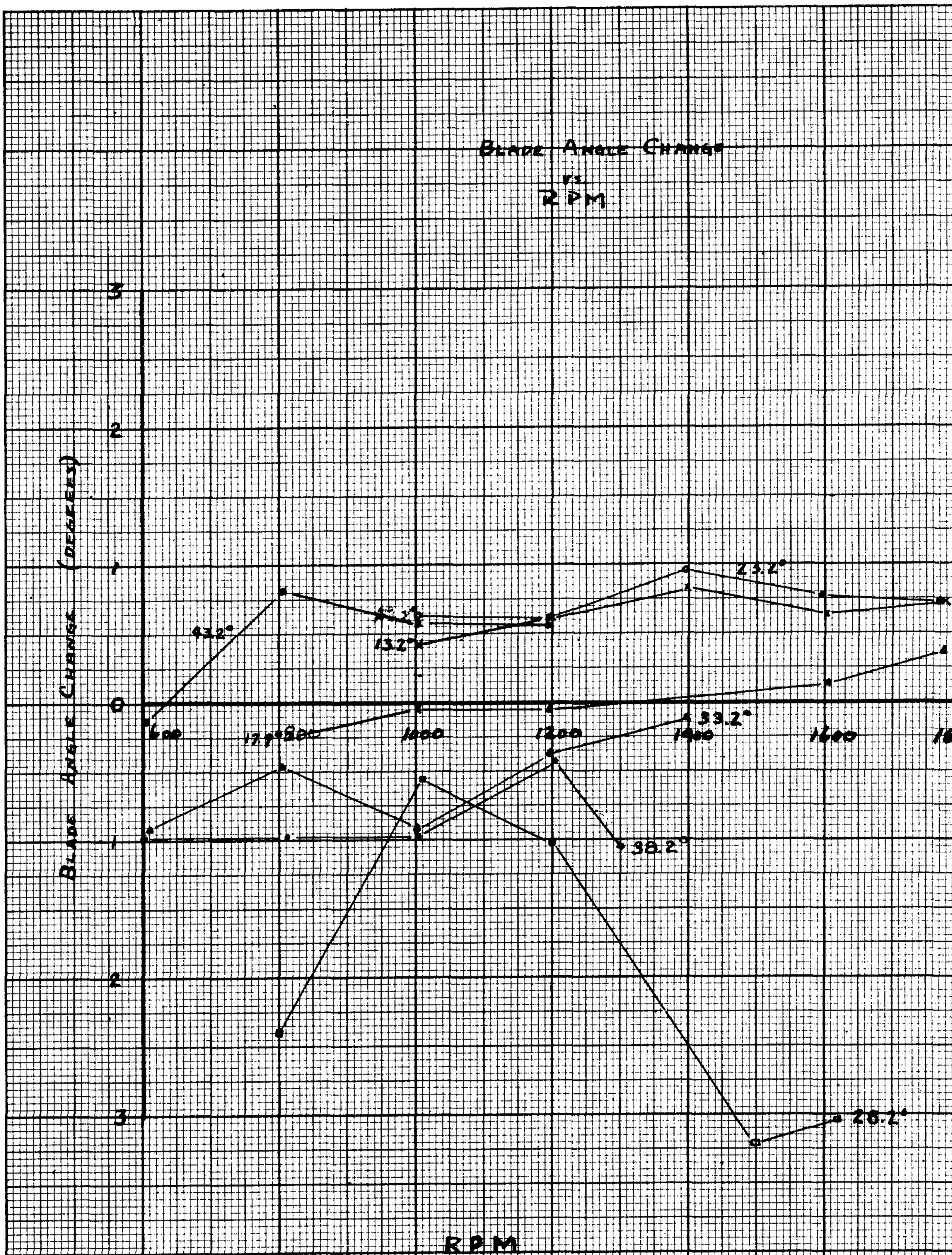

Fig 14 - Blade Angle Change Plotted Against RPM
Aeroproducts Model A422-49 Propeller.

R.Z.S.

WHIRL TEST No. 2273

TABLE 1

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected	DEFLECTIONS L. E.	DEFLECTIONS T. E.	DEFLECTIONS Angle	REMARKS*

CALIBRATION DATA

AEROPRODUCTS 2-BLADE 10 FT. 1/2 IN. DIAMETER PROPELLER
BLADE DESIGN NO. H20H-162-40M5
HUB DESIGN NO. A422-E1

Blade Angles Measured at 42 Inch Station
Blade Deflections Measured at 42 Inch Station

Blade Angle Set at +13.2°

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected	L. E.	T. E.	Angle
10:21	1004	66	64	648	+0.20	+0.11	+0.416
	1200	112	107	913	+0.20	+0.07	+0.602
	1398	187	171	1275	+0.26	+0.08	+0.833
	1605	286	274	1719	+0.29	+0.15	+0.647
10:31	1780	419	402	2174	+0.31	+0.15	+0.740

Blade Angle Set at +17.9°

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected	L. E.	T. E.	Angle
13:31	815	59	58	553	+0.08	+0.13	-0.234
	1004	117	116	828	+0.12	+0.13	-0.047
	1196	195	193	1213	+0.15	+0.16	-0.047
	1606	495	490	2243	+0.22	+0.19	+0.141
13:40	1776	703	696	2880	+0.27	+0.19	+0.376

Blade Angle Set at +23.2°

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected	L. E.	T. E.	Angle
	1006	215	207	1038	+0.10	-0.03	+0.635
	1198	370	357	1483	+0.13	0.00	+0.635
	1397	602	580	2076	+0.16	-0.04	+0.978
	1593	933	899	2730	+0.19	+0.03	+0.782
	1768	1299	1250	3410	+0.20	+0.05	+0.732

Blade Angle Set at +26.5°

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected
10:07	805	178	169	665
	1005	333	315	1060
	1207	578	547	1615
	1355	794	751	2490
10:20	1636	1400	1325	3480

WHIRL TEST No. 2273

TABLE 2

Time	R. P. M.	H. P. Actual	H. P. Corrected	Thrust Corrected	DEFLECTIONS L. E.	DEFLECTIONS T. E.	DEFLECTIONS Angle	REMARKS*
Blade Angle Set at +28.2°								
14:28	806	165	159	785	+ .08	+0.48	-2.40	
	1010	342	329	1235	+ .14	+0.25	-0.560	
	1200	576	555	1705	+ .20	+0.40	-1.02	
	1348	817	786	2175				
	1500	1140	1097	2702	+ .27	+0.90	-3.21	
	1622	1469	1415	3210	+ .25	+0.85	-3.06	
Blade Angle Set at +33.2°								
12:18	610	90	89	506	+0.05	+0.22	-0.915	
	807	220	217	848	+0.09	+0.17	-0.431	
	1002	429	423	1324	+0.15	+0.32	-0.915	
	1192	748	738	1838	+0.19	+0.25	-0.363	
12:25	1394	1195	1178	2520	+0.24	+0.26	-0.108	
Blade Angle Set at +38.2°								
08:30	600	126	123	494	+0.08	+0.25	-0.975	
	812	300	292	863	+0.14	+0.31	-0.975	
	1002	567	551	1312	+0.16	+0.33	-0.975	
	1206	993	965	1907	+0.21	+0.28	-0.401	
08:45	1300	1250	1215	2206	+0.22	+0.42	-1.05	
Blade Angle Set at +43.2°								
10:10	602	137	133	495	+0.06	+0.08	-0.123	
	806	340	331	869	+0.13		+0.803	
	1004	679	670	1314	+0.16	+0.05	+0.680	
10:18	1192	1176	1144	1838	+0.20	+0.10	+0.618	

WHIRL TEST No. 2273

TABLE 3

Time	R. P. M.	H. P.		Thrust Corrected	DEFLECTIONS			REMARKS*
		Actual	Corrected		L. E.	T. E.	Angle	

CALIBRATION DATA

AEROPRODUCTS 2-BLADE 10 FT. 1/2 IN. DIAMETER PROPELLER
BLADE DESIGN NO. H20H1-162-40M5
HUB DESIGN NO. A422-E1

With Rubber Bonded Balance Cups

Blade Angles Measured at 42 Inch Station
Blade Deflections Measured at 42 Inch Station

Blade Angle Set at +17.9°

09:00	1775	716	750	2830

Difficulties Encountered in Engine Running

After ten hours of operation, difficulty was experienced in the movement of the control arm to effect a change in control conditions. Investigation revealed that the threads in the control ring had worn, causing cocking of the bronze control ring on the pump power gear assembly. An attempt was made to prevent thread wear by using two bronze control rings held apart by springs as shown in Figure 15. It was intended that the springs would keep the control ring pressed against one side of the threads and thus prevent excessive wear and take up backlash of the motion. However, after 24:30 hours of operation, the rivets in the spring-loaded control ring failed as shown in Figure 16. A control ring of nitriding steel was next used in the regulator and satisfactorily completed the type test.

At the first 25 hour inspection, it was found that the control ring guide pin had broken at the base as shown in Figure 17. This guide pin was replaced with a larger diameter pin which was found satisfactory at the end of the 100 hour endurance test plus an additional 25 hour penalty run due to the failed guide pin.

At the time the guide pin failed, the "C" washers which retain the two stop pins in the control ring were found broken. This type failure was identical to that on the Model A542-A1 propeller. It was found that the addition of an AN6227-1 "O" ring over the stop pin after the "C" washer was installed prevented damage to the washer. No further difficulty with this part was encountered.

After the first eight hours of operation, excessive galling of the rear cone and cone seat was noticed as shown in Figures 18, 19, and 20. The propeller was removed, the cone seat lapped, a new cone installed, and the propeller was replaced with the torque measured at 800 ft-lb. on the propeller shaft retaining nut. It was found by repeated tests, however, that the necessary torque to prevent galling was 1200 ft-lb. After the retaining nut was tightened to 1200 ft-lb., no galling of the cones was encountered.

ADDITIONAL TESTS

After the completion of the type test, 24-1/2 hours of engine testing and one hour overspeed on the electric motor whirl rig were run to determine the suitability of rubber bonded balance cups in lieu of soldered balance cups in the same propeller configuration. The blades from the type test propeller were returned to Aeroproducts where the rubber-bonded balance cups were installed and the blades redesignated as Model H20H2-162-40M5. The same hub and regulator used in the type test were re-used for this test.

The whirl test was run at the same blade angle and speed that the overspeed condition of the original whirl test was run.

The engine test was intended to be a 25 hour test, but was stopped after 24-1/4 hours due to a failure of the adapter stop as shown in Figure 21. This time was considered satisfactory since there was no shift in the bonding or balance cups.

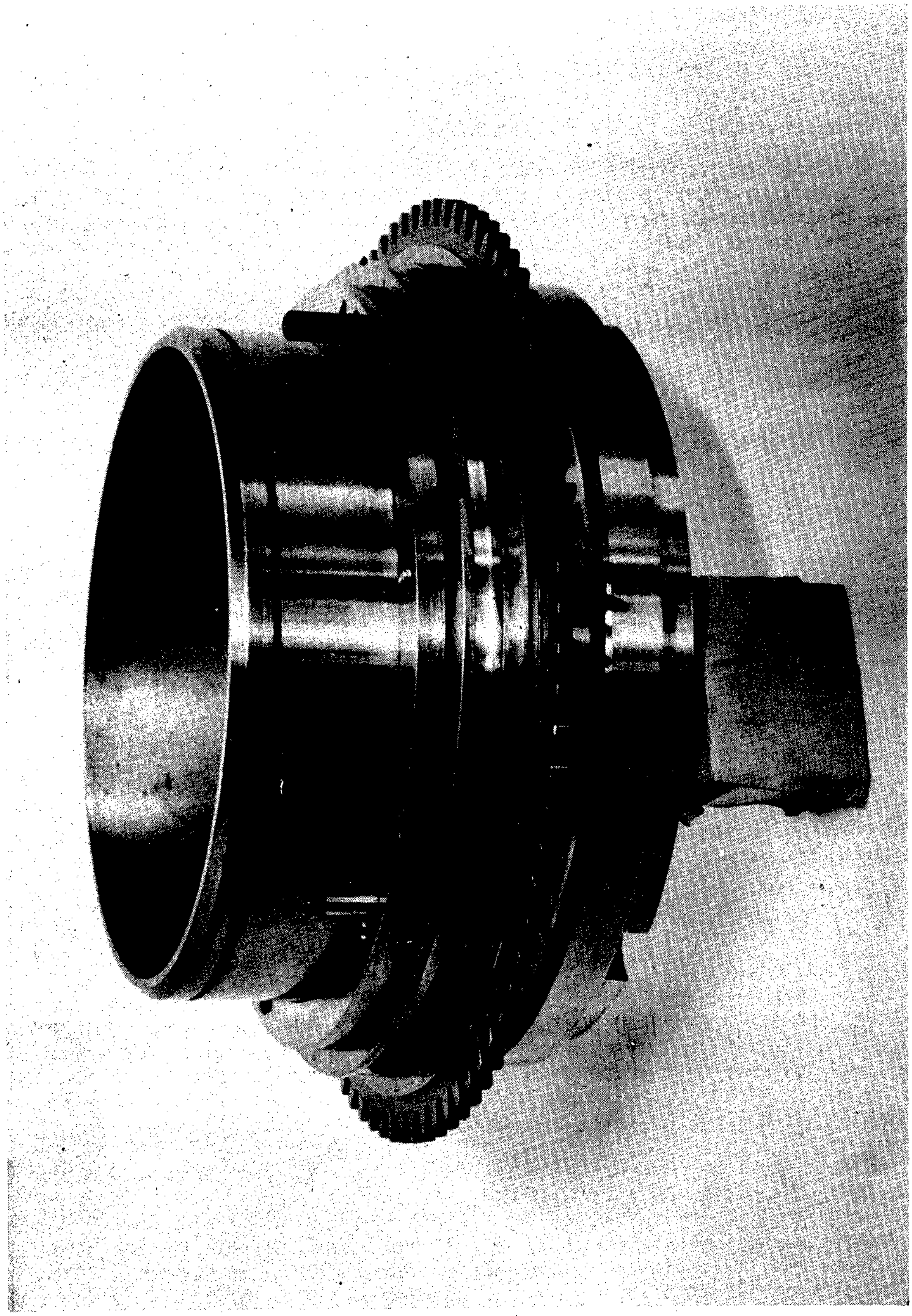

Fig 15 - Pump Power Gear Assembly, Showing
Spring Loaded Regulator Control Ring

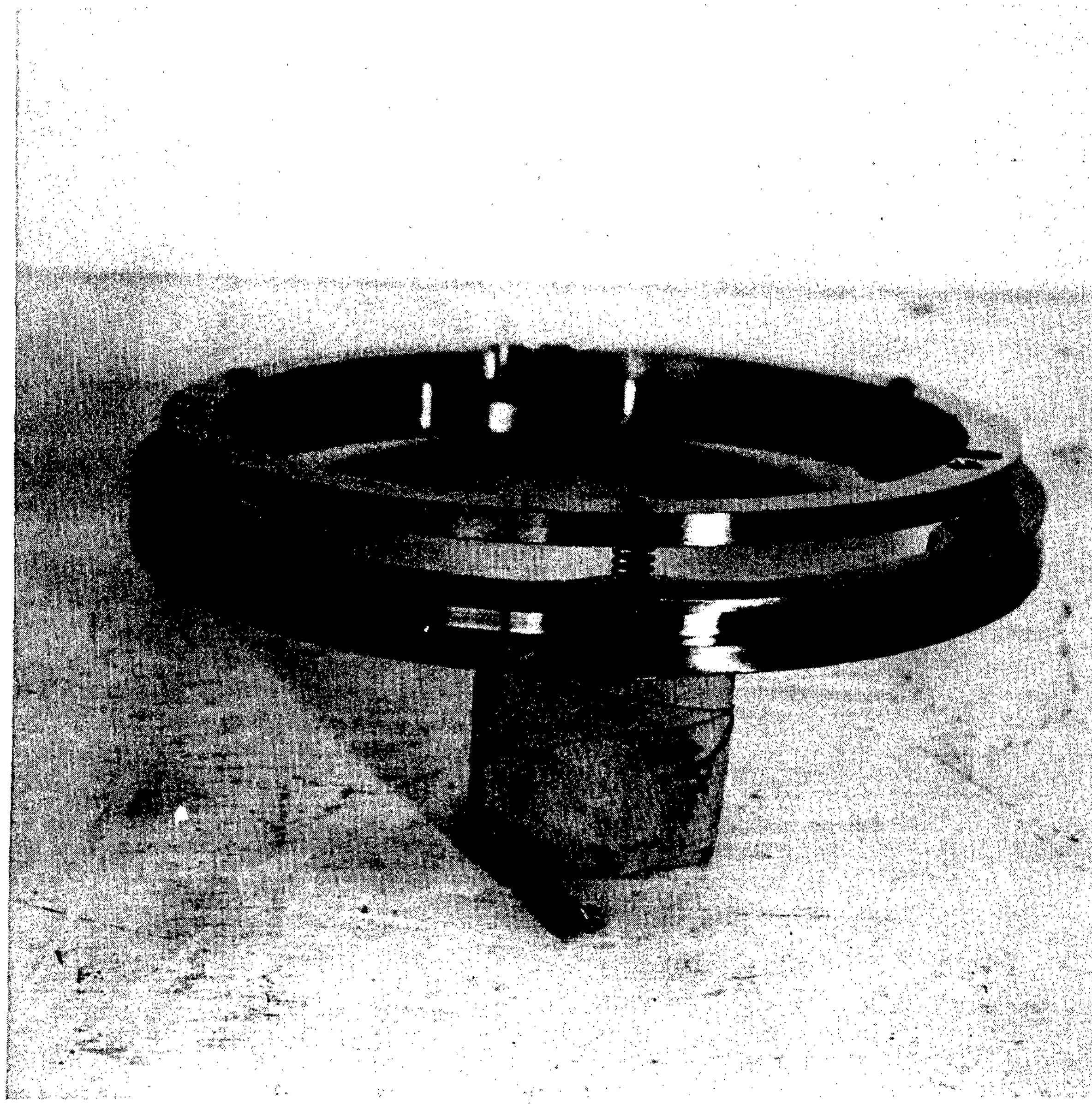

Fig 16 - Control Ring with Broken Rivet After 26:30 Hours on R-1300-1 Engine. Aeroproducts Model A422-69 Propeller.

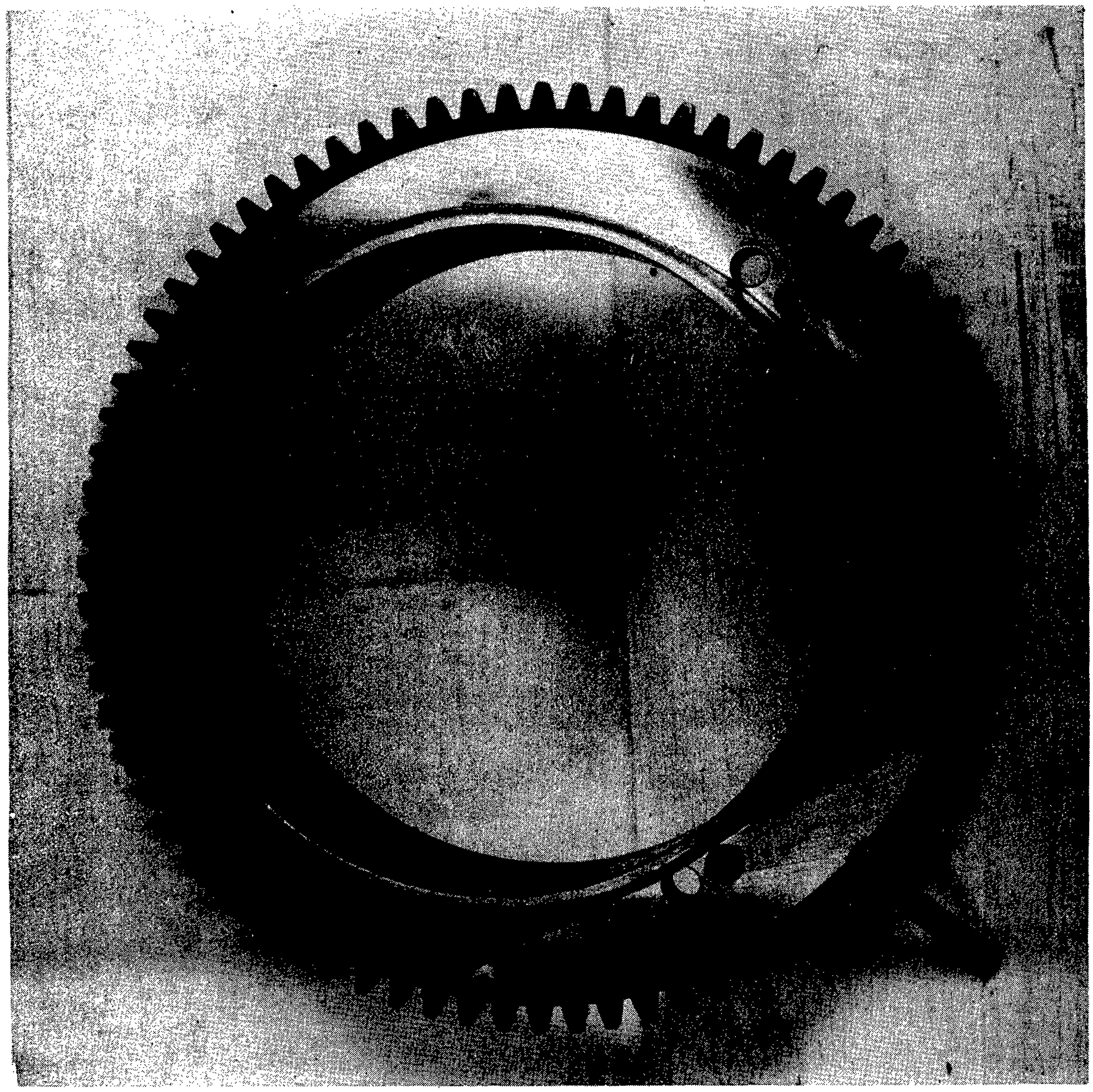

Fig 17 - Broken Guide Pin and Pump Power
From A422-69 Propeller Regulator

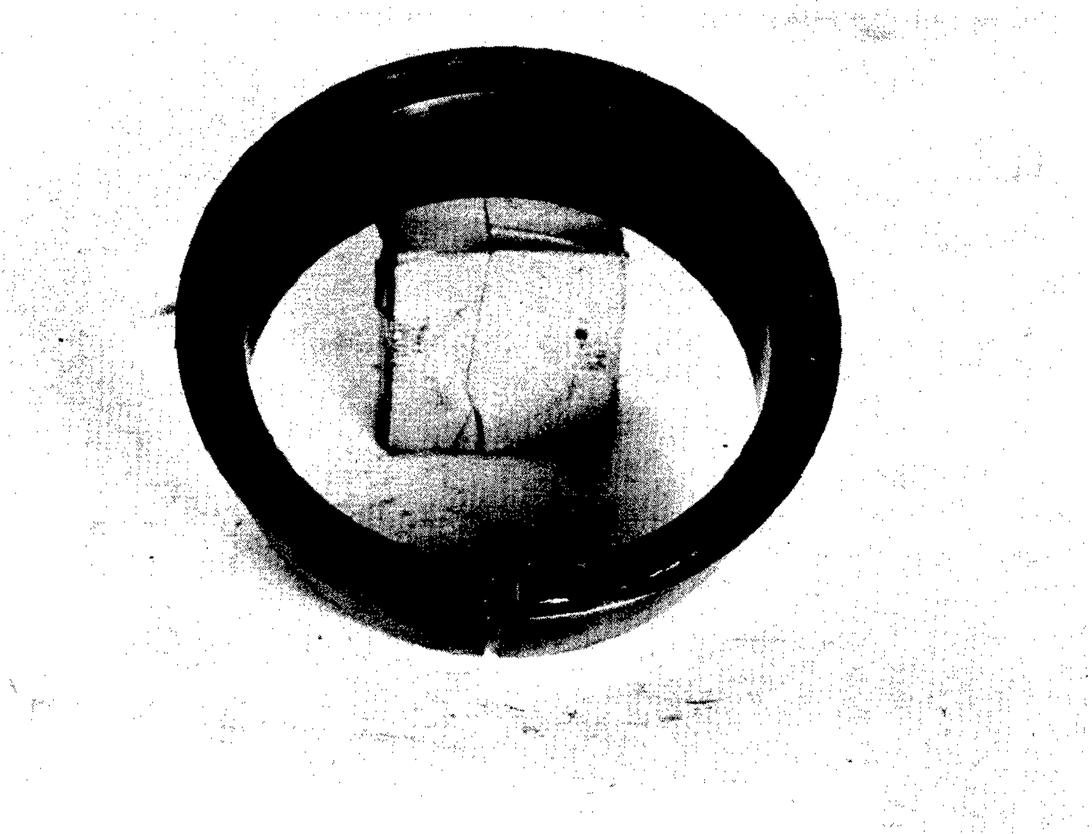

Fig 18 - Rear Face of Rear Cone. A422-69 Propeller On R-1300-1 Engine After 26:30 Hours of Operation

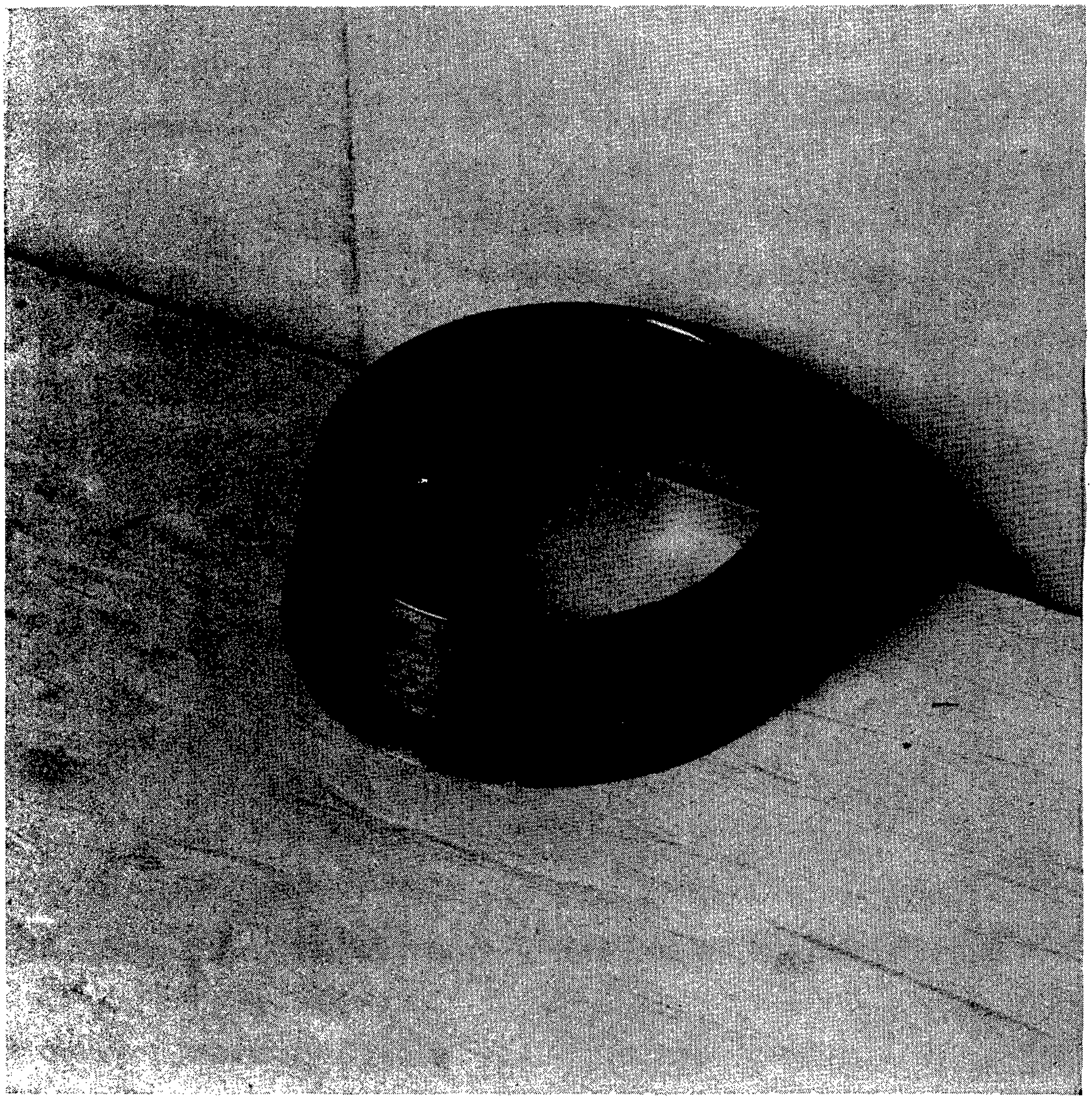

Fig 19 - Tapered Face of Rear Cone. A422-69 Propeller on R-1300-1 Engine After 26:30 Hours of Operation

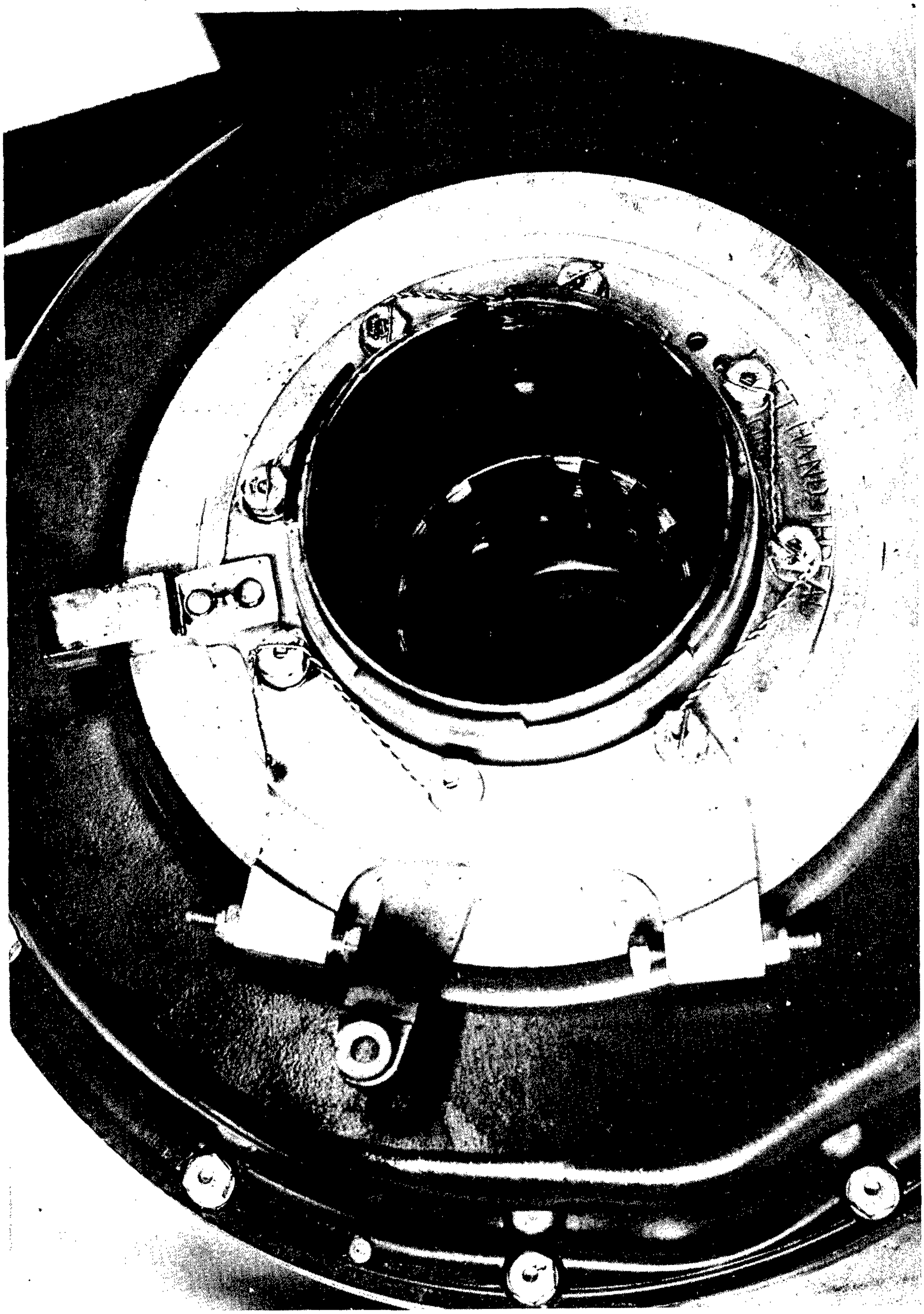

Fig 20 - Inside Face of Hub Rear Cone Seat. A422-69 Propeller on R-1300-1 Engine After 46:30 Hours of Operation.

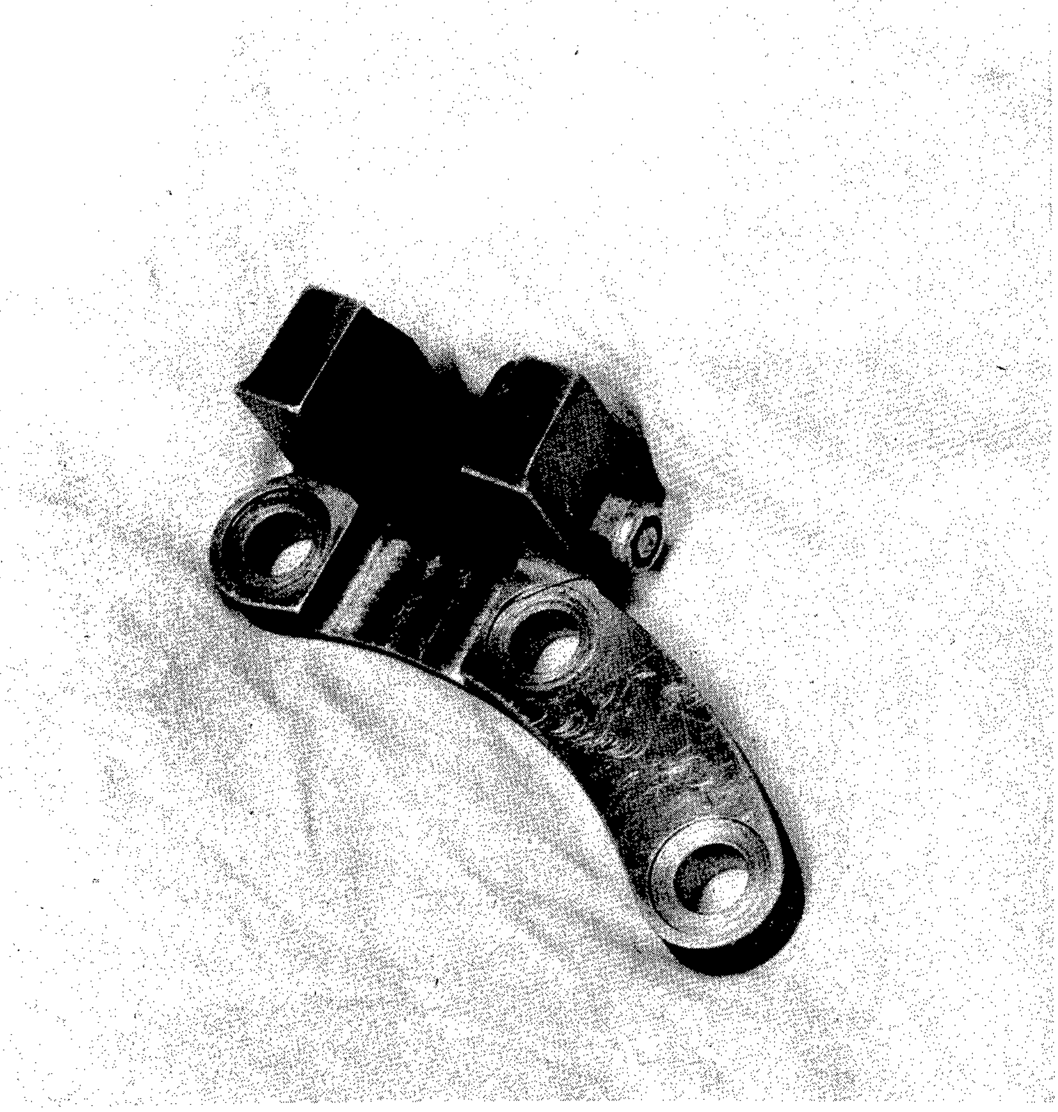

Fig 21 - Broken Adapter Stop From Aeroproducts A422-69 Propeller After 170:40 Hours on R-1300-1 Engine in Torque Stand.

RESULTS

The A422-69 propeller assembly satisfactorily completed the endurance and overspeed on the whirl rigs and the engine testing of this type test.

The use of rubber bonded cups is satisfactory in this propeller as determined from this test.

An inspection of the propeller after test revealed that the blade retention bearings were galled slightly as shown in Figures Nos. 22, 23, and 24. However, since this galling was not worse than other cases noted in service, it was felt that there was no necessity for change or for further testing.

Two changes were made in the propeller during testing, (1) the bronze control ring was replaced by a control ring of nitriding steel, and (2) the guide pin for the control ring was replaced with a guide pin of larger diameter. Both of these changed parts satisfactorily completed 100 hours of endurance operation.

CONCLUSIONS

From the results of this test, it is concluded that the Aeroproducts propeller assembly, Model No. A422-E1, is satisfactory for use on the T-28 aircraft in combination with the R-1300-1 engine.

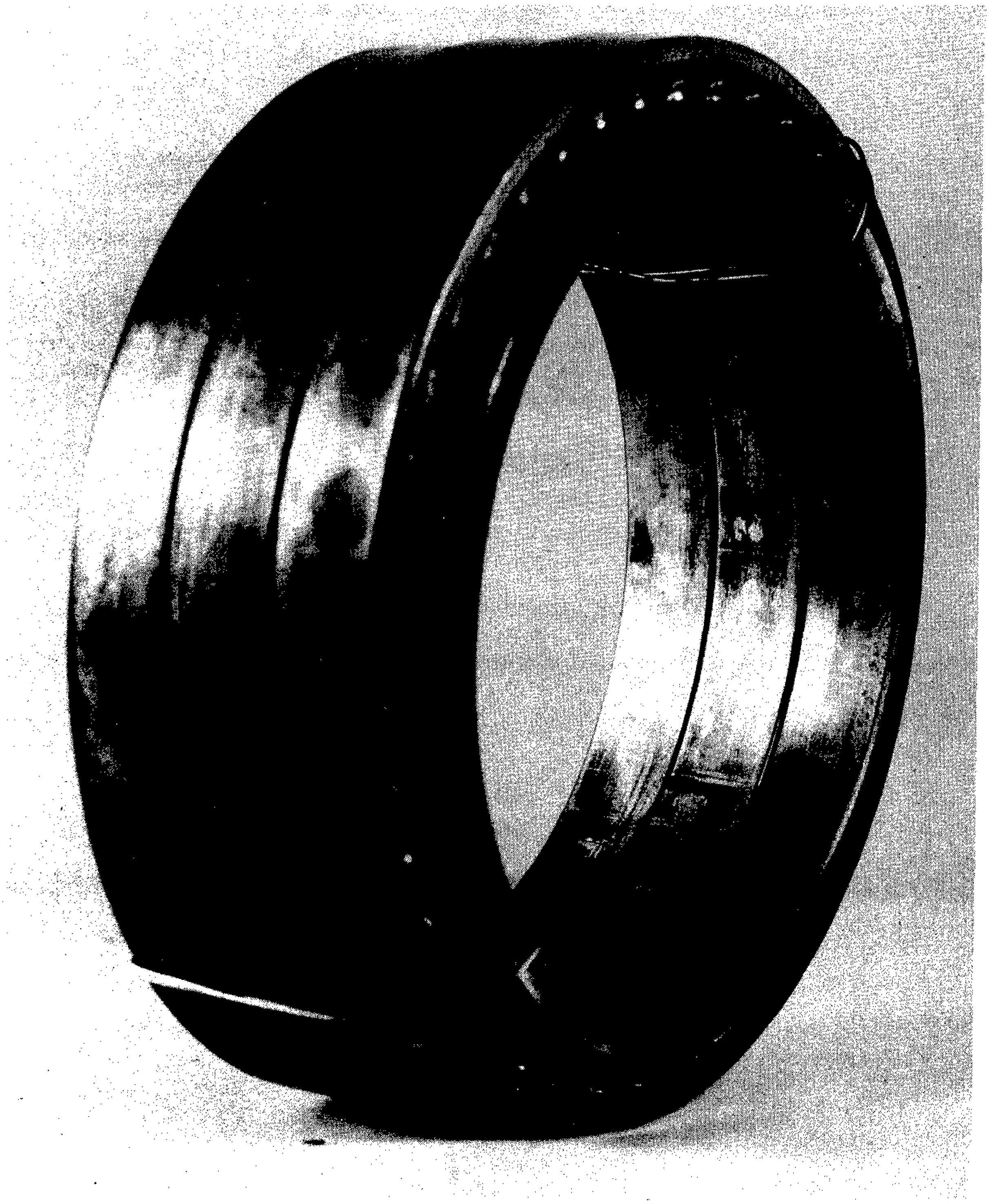

Fig 22 - Side View Galled Blade Bearings. Aeroproducts A422-69 Propeller After 170:40 Hours on R-1300-1 Engine in Torque Stand.

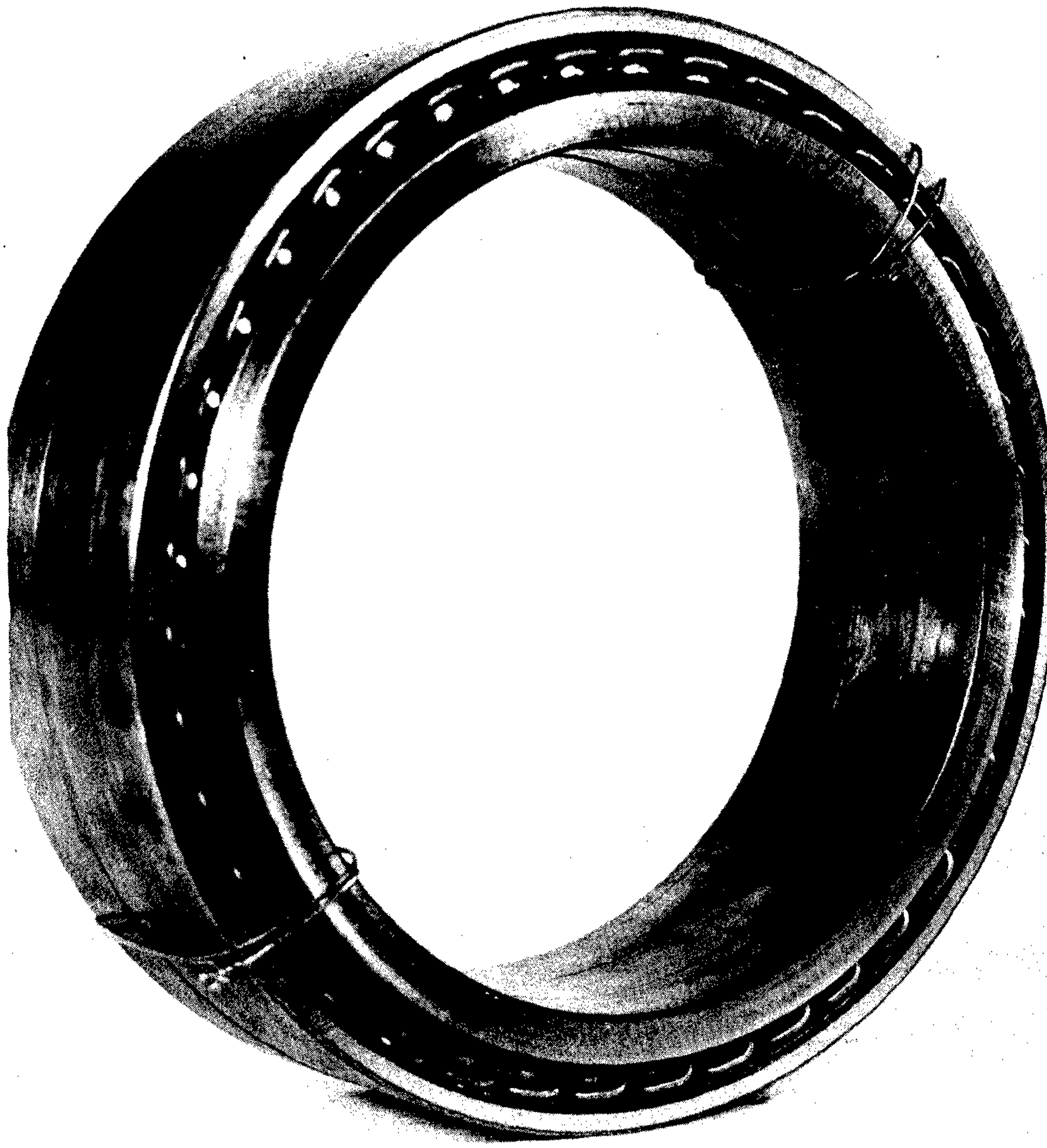

Fig 23 - Front View Galled Blade Bearings. Aeroproducts A422-69 Propeller After 170:40 Hours on R-1300-1 Engine in Torque Stand.

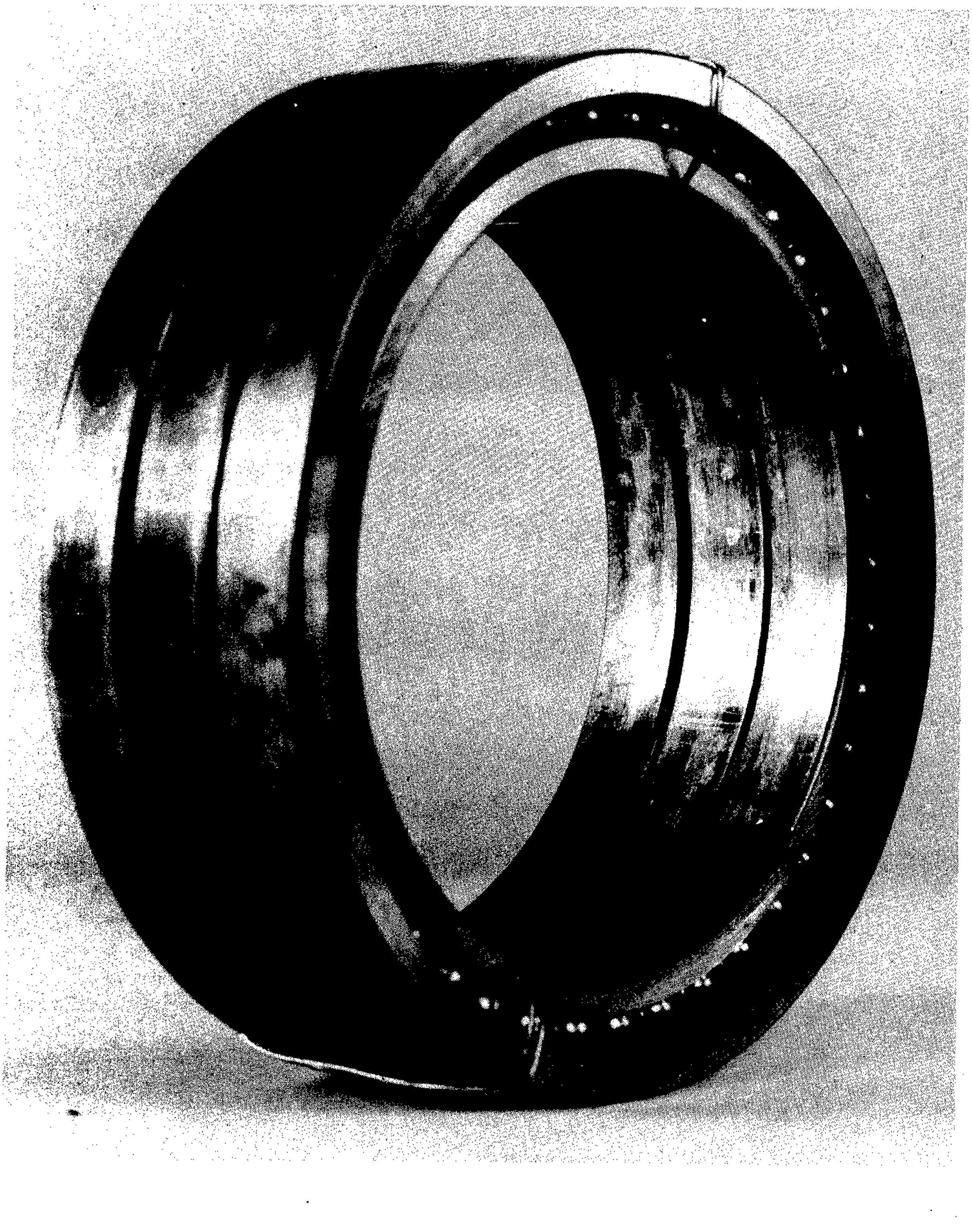

Fig 24 - Back View, Galled Blade Bearings. Aeroproducts A422-69 Propeller After 170:40 Hours on R-1300-1 Engine in Torque Stand.

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Aeroproducts Division
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